Capstone_6_Glove

March 7, 2024

[1]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

[2]:
```
import tensorflow as tf
import pandas as pd
import numpy as np
import random
```

[3]:
```
random.seed(10)
```

[4]:
```
df = pd.read_csv("/content/drive/MyDrive/Capstone Semester 6/
↪software_requirements_extended.csv")
```

[5]:
```
df.head(5)
```

[5]:

	Type	Requirement
0	PE	The system shall refresh the display every 60 …
1	LF	The application shall match the color of the s…
2	US	If projected the data must be readable. On …
3	A	The product shall be available during normal …
4	US	If projected the data must be understandable…

1 Preprocessing raw data

1. Removing stopwords
2. lemmetization
3. Removing unwanted symbols
4. Lowercasing

[6]:
```
import nltk
nltk.download('stopwords')
nltk.download('wordnet')
import re
import string
import numpy as np
from nltk.corpus import stopwords
```

```
from nltk.tokenize import TweetTokenizer
from nltk.stem import WordNetLemmatizer
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data…
[nltk_data]   Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package wordnet to /root/nltk_data…
```

[7]:
```
lemmatizer = WordNetLemmatizer()
stopwords_english = stopwords.words('english')
lemmatizer = WordNetLemmatizer()
tokens = TweetTokenizer(preserve_case=False, strip_handles=True,reduce_len=True)

def process_text(text):
  text = re.sub(r'\d', '',text)
  unwanted_symbols = ['€', ' ', 'â', '<','%']
  for symbol in unwanted_symbols:
    text = text.replace(symbol, '')

  text_tokens = tokens.tokenize(text)
  clean_text=""
  for word in text_tokens:
    if (word not in stopwords_english and  word not in string.punctuation):
      if len(word)<=2:
        continue
      lemma_word = lemmatizer.lemmatize(word)
      clean_text = clean_text + " " + lemma_word
  return clean_text.lower()
df['cleaned_text'] = df['Requirement'].apply(process_text)
```

[8]:
```
df.head()
```

[8]:
```
  Type                                          Requirement  \
0   PE  The system shall refresh the display every 60 …
1   LF  The application shall match the color of the s…
2   US   If projected  the data must be readable.  On …
3    A   The product shall be available during normal …
4   US   If projected  the data must be understandable…

                                       cleaned_text
0          system shall refresh display every second
1   application shall match color schema set fort…
2   projected data must readable projection scree…
3   product shall available normal business hour …
4   projected data must understandable projection…
```

[111]:
```
X = df.iloc[:,2]
y = df["Type"]
```

2 Label encoding the output class

[112]:
```
from sklearn.preprocessing import LabelEncoder

encoder = LabelEncoder()

y = encoder.fit_transform(y)
```

[113]:
```
y
```

[113]:
```
array([ 9,  5, 13,  0, 13, 12, 13,  9,  1,  1,  1,  4,  4,  4,  1,  1,  1,
        1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  1,  8,  8,  8,  8,  8,  5,  5,  5, 10, 13, 13, 13,
       13, 13,  9,  9,  9,  9,  0,  0, 11, 11, 11,  8,  8,  8,  8,  8, 12,
       12, 12, 12, 12, 12, 12,  4,  4,  4,  1,  1,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  8,  8,  8,  8,  8,  5,
        5, 13, 13, 13, 13, 13, 13, 13, 13, 13,  9,  0,  3, 11, 11, 11,  8,
        8,  8,  8,  8,  8,  8, 13,  6,  6,  6, 13,  6, 13,  8,  8, 12, 12,
       12, 12,  3, 12, 11, 13,  8,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
        9,  9,  8,  8, 12, 12,  4,  8,  1,  1,  1,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  1,  1,  9,  9,  9,  9,  9,  9,  9,  9,  9,  9,  9,
        5,  5,  5, 13, 13, 13, 13, 13, 13, 13, 13, 13,  9,  9,  9,  9, 12,
        0,  0,  0,  3,  3, 11, 11, 11, 11,  6,  8,  8,  8,  8,  8,  8,  8,
        6,  9,  9,  0, 13,  0,  8, 12, 12, 12, 12, 12, 12, 12, 12, 12, 12,
       12, 12, 12, 12,  5,  5,  5,  8,  4,  4,  4,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  9,  9,  9,
        9,  8,  8,  0,  6,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  5,  5,  5,  5,  5,  5,  5,  0,  9,  9,  9, 13, 13,
       12,  9,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,  1,
        1,  1,  1,  1,  1,  1, 13, 13,  9,  9,  9,  0,  0,  6, 12, 12, 12,
        5,  5,  5,  5, 13, 13, 13,  9,  9,  9,  9,  9,  0,  3,  3, 11,  8,
        8,  6,  6,  6, 12, 12, 12,  5,  5,  5,  5, 13, 13, 13, 13, 13, 13,
        0, 11, 11,  8,  8,  6,  6, 12, 12, 12, 12,  5,  5,  5, 13, 13, 13,
       13,  9,  0,  8,  9,  9,  8,  8,  8,  0,  5,  5, 13, 13, 13, 13,  9,
        9,  9,  9,  9,  9,  0,  0,  3,  3,  3,  3, 11, 11, 11, 13, 13, 10,
       12, 12, 12,  1,  1,  1,  1, 11, 11, 11, 11,  8,  8,  8,  1,  1,  1,
        1,  1, 13, 13, 13, 13, 13, 13, 13, 13,  9,  9,  0,  8,  8,  8,  8,
        8, 12, 12, 12, 12, 12, 12, 12, 12, 12, 12,  1,  1,  1,  1,  1,  1,
        1,  6,  6,  1,  1,  1,  1,  1,  1,  1,  1,  1,  0,  8,  8,  8,  6,
        6, 12, 12,  5,  5, 13,  9,  1,  1,  1,  1,  2,  2,  7,  2,  7,  2,
        2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,
        2,  2,  2,  2,  7,  7,  7,  7,  7,  7,  2,  2,  2,  2,  2,  2,  2,
        2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  7,
        7,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,
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2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,
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7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,
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7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,
7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,
7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  7,  2,
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2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,  2,
2,  2,  2,  2,  2,  2,  2,  2])
```

3 Stratified Spliting of Data into train and test set

[114]:
```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.
↪2,stratify=y,random_state=1)
```

4 Converting text to numeric sequences

[115]:
```
from tensorflow.keras import preprocessing
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
```

[116]:
```
# Embedding layer expects the words to be in numeric form
# Using Tokenizer function from keras.preprocessing.text library
# Method fit_on_text trains the tokenizer
# Method texts_to_sequences converts sentences to their numeric form

word_tokenizer = Tokenizer()
word_tokenizer.fit_on_texts(X)

X_train = word_tokenizer.texts_to_sequences(X_train)
X_test = word_tokenizer.texts_to_sequences(X_test)
```

[117]:
```
X_train[0]
```

[117]:
```
[233, 226, 194, 1729, 233, 530, 143]
```

[118]:
```
# Adding 1 to store dimensions for words for which no pretrained word␣
↪embeddings exist

vocab_length = len(word_tokenizer.word_index) + 1

vocab_length
```

[118]:
```
1823
```

[119]:
```
# Padding all reviews to fixed length 100

maxlen = 30

X_train = pad_sequences(X_train, padding='post', maxlen=maxlen)
X_test = pad_sequences(X_test, padding='post', maxlen=maxlen)
X_train[0]
```

[119]:
```
array([ 233,  226,  194, 1729,  233,  530,  143,    0,    0,    0,    0,
           0,    0,    0,    0,    0,    0,    0,    0,    0,    0,    0,
           0,    0,    0,    0,    0,    0,    0,    0], dtype=int32)
```

[120]:
```
!mkdir ~/.kaggle
!cp kaggle.json ~/.kaggle/
```

```
mkdir: cannot create directory ‘/root/.kaggle’: File exists
```

[121]:
```
!chmod 600 ~/.kaggle/kaggle.json
```

[122]:
```
!kaggle datasets download -d sawarn69/glove6b100dtxt
```

```
glove6b100dtxt.zip: Skipping, found more recently modified local copy (use
--force to force download)
```

[123]:
```
!unzip /content/glove6b100dtxt.zip
```

```
Archive:  /content/glove6b100dtxt.zip
replace glove.6B.100d.txt? [y]es, [n]o, [A]ll, [N]one, [r]ename:
```

[36]:
```
# Load GloVe word embeddings and create an Embeddings Dictionary

from numpy import asarray
from numpy import zeros

embeddings_dictionary = dict()
glove_file = open('/content/glove.6B.100d.txt')

for line in glove_file:
```

```
    records = line.split()
    word = records[0]
    vector_dimensions = asarray(records[1:], dtype='float32')
    embeddings_dictionary [word] = vector_dimensions
glove_file.close()
```

[37]:
```
# Create Embedding Matrix having 100 columns
# Containing 100-dimensional GloVe word embeddings for all words in our corpus.

embedding_matrix = zeros((vocab_length, 100))
for word, index in word_tokenizer.word_index.items():
    embedding_vector = embeddings_dictionary.get(word)
    if embedding_vector is not None:
        embedding_matrix[index] = embedding_vector
```

[38]:
```
embedding_matrix.shape
```

[38]:
```
(1823, 100)
```

[39]:
```
import matplotlib.pyplot as plt
from sklearn.metrics import classification_report

# Function to plot training history
def plot_history(history):
    plt.figure(figsize=(12, 6))

    # Plot training & validation accuracy values
    plt.subplot(1, 2, 1)
    plt.plot(history.history['acc'])
    plt.plot(history.history['val_acc'])
    plt.title('Model accuracy')
    plt.xlabel('Epoch')
    plt.ylabel('Accuracy')
    plt.legend(['Train', 'Validation'], loc='upper left')

    # Plot training & validation loss values
    plt.subplot(1, 2, 2)
    plt.plot(history.history['loss'])
    plt.plot(history.history['val_loss'])
    plt.title('Model loss')
    plt.xlabel('Epoch')
    plt.ylabel('Loss')
    plt.legend(['Train', 'Validation'], loc='upper left')

    plt.show()
```

5 LSTM Model 1

[124]:
```
from keras.layers import LSTM, Dense, Embedding, Dropout
from keras.models import Sequential

lstm_mod1 = Sequential()
embedding_layer = Embedding(vocab_length, 100, weights=[embedding_matrix],␣
 ↪input_length=maxlen , trainable=False)
lstm_mod1.add(embedding_layer)
lstm_mod1.add(LSTM(128, return_sequences=True))
lstm_mod1.add(Dropout(0.2))
lstm_mod1.add(LSTM(128))
lstm_mod1.add(Dense(14, activation='softmax'))
lstm_mod1.compile(optimizer='adam', loss=tf.keras.losses.
 ↪SparseCategoricalCrossentropy(), metrics=['acc'])
```

[125]:
```
print(f"Summary of LSTM Model 1:")
print(lstm_mod1.summary())
```

```
Summary of LSTM Model 1:
Model: "sequential_13"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding_13 (Embedding)    (None, 30, 100)           182300

 lstm_29 (LSTM)              (None, 30, 128)           117248

 dropout_19 (Dropout)        (None, 30, 128)           0

 lstm_30 (LSTM)              (None, 128)               131584

 dense_16 (Dense)            (None, 14)                1806

=================================================================
Total params: 432938 (1.65 MB)
Trainable params: 250638 (979.05 KB)
Non-trainable params: 182300 (712.11 KB)
_________________________________________________________________
None
```

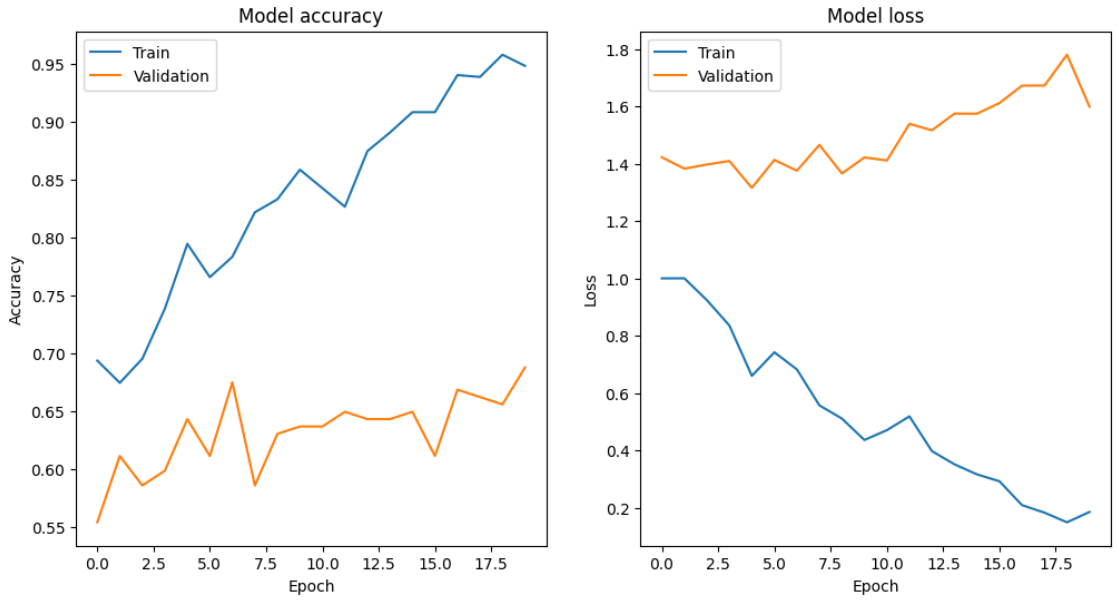
[126]:
```
X_train.shape
```

[126]:
```
(781, 30)
```

[128]:
```
history = lstm_mod1.fit(X_train, y_train,epochs=20, verbose=1,␣
 ↪validation_split=0.2)
plot_history(history)
```

```
Epoch 1/20
20/20 [==============================] - 4s 215ms/step - loss: 1.0007 - acc:
0.6939 - val_loss: 1.4231 - val_acc: 0.5541
Epoch 2/20
20/20 [==============================] - 5s 249ms/step - loss: 1.0009 - acc:
0.6747 - val_loss: 1.3832 - val_acc: 0.6115
Epoch 3/20
20/20 [==============================] - 3s 128ms/step - loss: 0.9247 - acc:
0.6955 - val_loss: 1.3978 - val_acc: 0.5860
Epoch 4/20
20/20 [==============================] - 2s 102ms/step - loss: 0.8364 - acc:
0.7388 - val_loss: 1.4100 - val_acc: 0.5987
Epoch 5/20
20/20 [==============================] - 2s 103ms/step - loss: 0.6606 - acc:
0.7949 - val_loss: 1.3163 - val_acc: 0.6433
Epoch 6/20
20/20 [==============================] - 2s 112ms/step - loss: 0.7428 - acc:
0.7660 - val_loss: 1.4139 - val_acc: 0.6115
Epoch 7/20
20/20 [==============================] - 2s 119ms/step - loss: 0.6831 - acc:
0.7837 - val_loss: 1.3761 - val_acc: 0.6752
Epoch 8/20
20/20 [==============================] - 5s 231ms/step - loss: 0.5577 - acc:
0.8221 - val_loss: 1.4663 - val_acc: 0.5860
Epoch 9/20
20/20 [==============================] - 5s 227ms/step - loss: 0.5117 - acc:
0.8333 - val_loss: 1.3667 - val_acc: 0.6306
Epoch 10/20
20/20 [==============================] - 4s 181ms/step - loss: 0.4370 - acc:
0.8590 - val_loss: 1.4224 - val_acc: 0.6369
Epoch 11/20
20/20 [==============================] - 2s 115ms/step - loss: 0.4713 - acc:
0.8429 - val_loss: 1.4119 - val_acc: 0.6369
Epoch 12/20
20/20 [==============================] - 3s 147ms/step - loss: 0.5194 - acc:
0.8269 - val_loss: 1.5395 - val_acc: 0.6497
Epoch 13/20
20/20 [==============================] - 4s 196ms/step - loss: 0.3982 - acc:
0.8750 - val_loss: 1.5171 - val_acc: 0.6433
Epoch 14/20
20/20 [==============================] - 2s 118ms/step - loss: 0.3522 - acc:
0.8910 - val_loss: 1.5752 - val_acc: 0.6433
Epoch 15/20
20/20 [==============================] - 2s 114ms/step - loss: 0.3171 - acc:
0.9087 - val_loss: 1.5749 - val_acc: 0.6497
Epoch 16/20
20/20 [==============================] - 2s 113ms/step - loss: 0.2930 - acc:
0.9087 - val_loss: 1.6121 - val_acc: 0.6115
```

```
Epoch 17/20
20/20 [==============================] - 2s 111ms/step - loss: 0.2099 - acc:
0.9407 - val_loss: 1.6728 - val_acc: 0.6688
Epoch 18/20
20/20 [==============================] - 3s 127ms/step - loss: 0.1836 - acc:
0.9391 - val_loss: 1.6732 - val_acc: 0.6624
Epoch 19/20
20/20 [==============================] - 4s 209ms/step - loss: 0.1499 - acc:
0.9583 - val_loss: 1.7807 - val_acc: 0.6561
Epoch 20/20
20/20 [==============================] - 3s 135ms/step - loss: 0.1860 - acc:
0.9487 - val_loss: 1.5996 - val_acc: 0.6879
```



[129]:
```
print("Evaluating LSTM Model 1")
test_loss, test_accuracy = lstm_mod1.evaluate(X_test, y_test, verbose=1)
print(f"Test Loss: {test_loss:.4f}, Test Accuracy: {test_accuracy:.4f}")

y_pred = np.argmax(lstm_mod1.predict([X_test]),1)

print(f"Classification Report for LSTM Model 1:")
print(classification_report(y_test, y_pred))
```

```
Evaluating LSTM Model 1
7/7 [==============================] - 0s 33ms/step - loss: 1.6313 - acc: 0.6633
Test Loss: 1.6313, Test Accuracy: 0.6633
7/7 [==============================] - 1s 28ms/step
Classification Report for LSTM Model 1:
              precision    recall  f1-score   support
```

```
              0       0.40      0.50      0.44         4
              1       0.63      0.76      0.69        42
              2       0.84      0.86      0.85        63
              3       0.00      0.00      0.00         2
              4       0.33      0.50      0.40         2
              5       0.67      0.29      0.40         7
              6       0.00      0.00      0.00         3
              7       0.71      0.68      0.70        22
              8       0.60      0.50      0.55        12
              9       0.67      0.18      0.29        11
             11       1.00      0.25      0.40         4
             12       0.40      0.73      0.52        11
             13       0.54      0.54      0.54        13

    accuracy                           0.66       196
   macro avg       0.52      0.44      0.44       196
weighted avg       0.67      0.66      0.65       196
```

6 LSTM Model 2

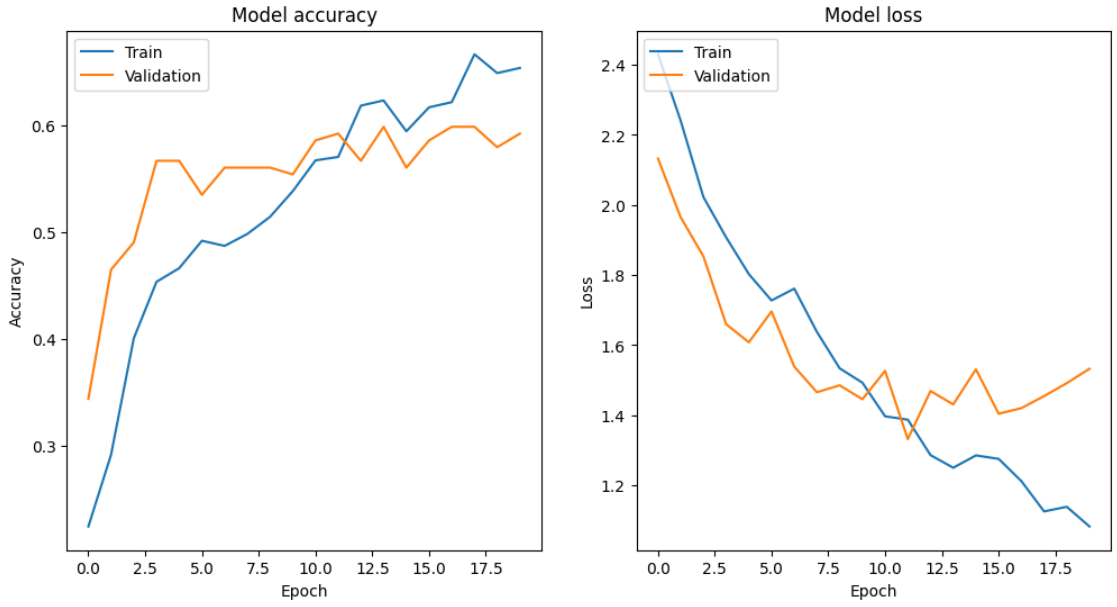
[130]:
```
lstm_mod2 = Sequential()
embedding_layer = Embedding(vocab_length, 100, weights=[embedding_matrix],␣
 ↪input_length=maxlen, trainable=False)
lstm_mod2.add(embedding_layer)
lstm_mod2.add(LSTM(128, return_sequences=True))
lstm_mod2.add(Dropout(0.2))
lstm_mod2.add(LSTM(128, return_sequences=True))
lstm_mod2.add(Dropout(0.2))
lstm_mod2.add(LSTM(64))
lstm_mod2.add(Dense(32, activation='relu'))
lstm_mod2.add(Dropout(0.2))
lstm_mod2.add(Dense(14, activation='sigmoid'))

lstm_mod2.compile(optimizer='adam', loss=tf.keras.losses.
 ↪SparseCategoricalCrossentropy(), metrics=['acc'])
```

[131]:
```
print(f"Summary of LSTM Model 2:")
print(lstm_mod2.summary())
```

```
Summary of LSTM Model 2:
Model: "sequential_14"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding_14 (Embedding)    (None, 30, 100)           182300
```

```
 lstm_31 (LSTM)              (None, 30, 128)           117248

 dropout_20 (Dropout)        (None, 30, 128)           0

 lstm_32 (LSTM)              (None, 30, 128)           131584

 dropout_21 (Dropout)        (None, 30, 128)           0

 lstm_33 (LSTM)              (None, 64)                49408

 dense_17 (Dense)            (None, 32)                2080

 dropout_22 (Dropout)        (None, 32)                0

 dense_18 (Dense)            (None, 14)                462

=================================================================
Total params: 483082 (1.84 MB)
Trainable params: 300782 (1.15 MB)
Non-trainable params: 182300 (712.11 KB)
_________________________________________________________________
None
```

[132]:
```
history = lstm_mod2.fit(X_train, y_train, epochs=20, verbose=1,␣
  ↪validation_split=0.2)
plot_history(history)
```



[133]:
```
print("Evaluating LSTM Model 2")
test_loss, test_accuracy = lstm_mod2.evaluate(X_test, y_test, verbose=1)
print(f"Test Loss: {test_loss:.4f}, Test Accuracy: {test_accuracy:.4f}")

y_pred = np.argmax(lstm_mod2.predict([X_test]),1)

print(f"Classification Report for LSTM Model 2:")
print(classification_report(y_test, y_pred))
```

```
Evaluating LSTM Model 2
7/7 [==============================] - 0s 36ms/step - loss: 1.3771 - acc: 0.6122
Test Loss: 1.3771, Test Accuracy: 0.6122
7/7 [==============================] - 1s 36ms/step
Classification Report for LSTM Model 2:
              precision    recall  f1-score   support

           0       0.00      0.00      0.00         4
           1       0.74      0.74      0.74        42
           2       0.77      0.97      0.86        63
           3       0.00      0.00      0.00         2
           4       0.00      0.00      0.00         2
           5       0.00      0.00      0.00         7
           6       0.00      0.00      0.00         3
           7       0.60      0.41      0.49        22
           8       0.30      0.67      0.41        12
           9       0.12      0.18      0.15        11
          11       0.00      0.00      0.00         4
          12       0.75      0.27      0.40        11
          13       0.46      0.46      0.46        13

    accuracy                           0.61       196
   macro avg       0.29      0.28      0.27       196
weighted avg       0.57      0.61      0.58       196


/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
```

```
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

7 LSTM Model 3

[134]:
```
from keras.layers import LSTM, Dense, Embedding, Dropout
from keras.models import Sequential

lstm_mod3 = Sequential()
embedding_layer = Embedding(vocab_length, 100, weights=[embedding_matrix],␣
 ↪input_length=maxlen , trainable=False)
lstm_mod3.add(embedding_layer)
lstm_mod3.add(LSTM(128, return_sequences=True))
lstm_mod3.add(Dropout(0.5))
lstm_mod3.add(LSTM(128))
lstm_mod3.add(Dense(14, activation='softmax'))
lstm_mod3.compile(optimizer='adam', loss=tf.keras.losses.
 ↪SparseCategoricalCrossentropy(), metrics=['acc'])
```

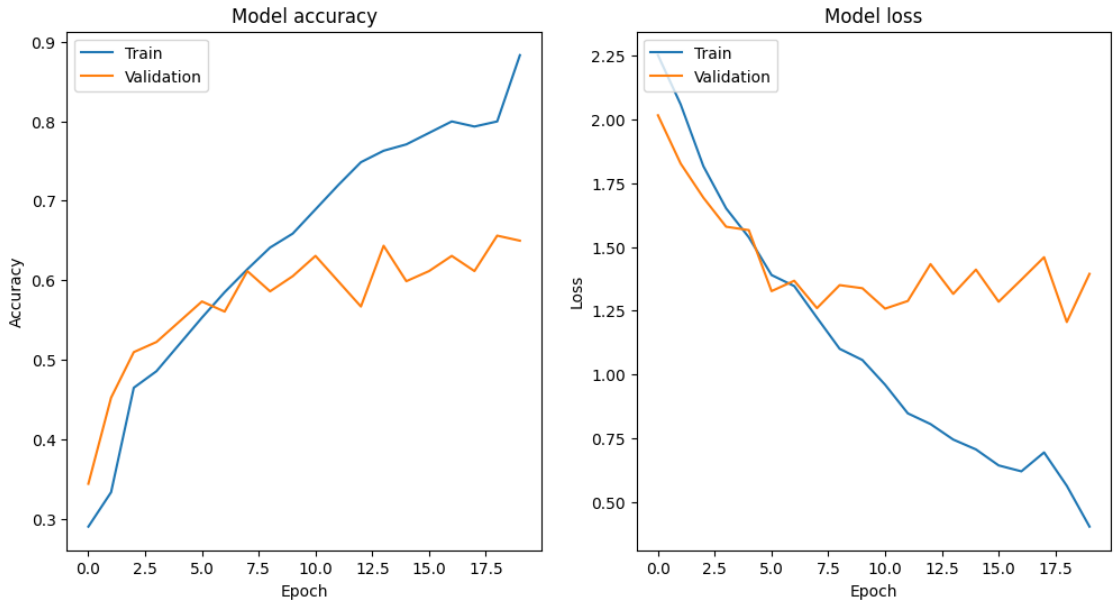
[135]:
```
print(f"Summary of LSTM Model 3:")
print(lstm_mod3.summary())
```

```
Summary of LSTM Model 3:
Model: "sequential_15"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding_15 (Embedding)    (None, 30, 100)           182300

 lstm_34 (LSTM)              (None, 30, 128)           117248

 dropout_23 (Dropout)        (None, 30, 128)           0

 lstm_35 (LSTM)              (None, 128)               131584

 dense_19 (Dense)            (None, 14)                1806

=================================================================
Total params: 432938 (1.65 MB)
Trainable params: 250638 (979.05 KB)
Non-trainable params: 182300 (712.11 KB)
_________________________________________________________________
None
```

[136]:
```
history = lstm_mod3.fit(X_train, y_train, epochs=20, verbose=1,␣
 ↪validation_split=0.2)
plot_history(history)
```

```
Epoch 1/20
20/20 [==============================] - 9s 218ms/step - loss: 2.2527 - acc:
0.2901 - val_loss: 2.0167 - val_acc: 0.3439
Epoch 2/20
20/20 [==============================] - 2s 102ms/step - loss: 2.0591 - acc:
0.3333 - val_loss: 1.8271 - val_acc: 0.4522
Epoch 3/20
20/20 [==============================] - 2s 105ms/step - loss: 1.8168 - acc:
0.4647 - val_loss: 1.6934 - val_acc: 0.5096
Epoch 4/20
20/20 [==============================] - 2s 97ms/step - loss: 1.6515 - acc:
0.4856 - val_loss: 1.5795 - val_acc: 0.5223
Epoch 5/20
20/20 [==============================] - 2s 94ms/step - loss: 1.5377 - acc:
0.5192 - val_loss: 1.5660 - val_acc: 0.5478
Epoch 6/20
20/20 [==============================] - 3s 151ms/step - loss: 1.3898 - acc:
0.5529 - val_loss: 1.3266 - val_acc: 0.5732
Epoch 7/20
20/20 [==============================] - 4s 191ms/step - loss: 1.3465 - acc:
0.5849 - val_loss: 1.3674 - val_acc: 0.5605
Epoch 8/20
20/20 [==============================] - 2s 97ms/step - loss: 1.2224 - acc:
0.6138 - val_loss: 1.2599 - val_acc: 0.6115
Epoch 9/20
20/20 [==============================] - 2s 98ms/step - loss: 1.1002 - acc:
0.6410 - val_loss: 1.3502 - val_acc: 0.5860
Epoch 10/20
20/20 [==============================] - 2s 91ms/step - loss: 1.0563 - acc:
0.6587 - val_loss: 1.3381 - val_acc: 0.6051
Epoch 11/20
20/20 [==============================] - 2s 93ms/step - loss: 0.9594 - acc:
0.6891 - val_loss: 1.2580 - val_acc: 0.6306
Epoch 12/20
20/20 [==============================] - 2s 96ms/step - loss: 0.8470 - acc:
0.7196 - val_loss: 1.2880 - val_acc: 0.5987
Epoch 13/20
20/20 [==============================] - 3s 151ms/step - loss: 0.8049 - acc:
0.7484 - val_loss: 1.4327 - val_acc: 0.5669
Epoch 14/20
20/20 [==============================] - 4s 202ms/step - loss: 0.7441 - acc:
0.7628 - val_loss: 1.3158 - val_acc: 0.6433
Epoch 15/20
20/20 [==============================] - 2s 96ms/step - loss: 0.7054 - acc:
0.7708 - val_loss: 1.4112 - val_acc: 0.5987
Epoch 16/20
20/20 [==============================] - 2s 94ms/step - loss: 0.6426 - acc:
0.7853 - val_loss: 1.2851 - val_acc: 0.6115
```

```
Epoch 17/20
20/20 [==============================] - 2s 93ms/step - loss: 0.6194 - acc:
0.7997 - val_loss: 1.3716 - val_acc: 0.6306
Epoch 18/20
20/20 [==============================] - 2s 96ms/step - loss: 0.6936 - acc:
0.7933 - val_loss: 1.4598 - val_acc: 0.6115
Epoch 19/20
20/20 [==============================] - 2s 96ms/step - loss: 0.5627 - acc:
0.7997 - val_loss: 1.2054 - val_acc: 0.6561
Epoch 20/20
20/20 [==============================] - 3s 172ms/step - loss: 0.4024 - acc:
0.8830 - val_loss: 1.3945 - val_acc: 0.6497
```



[137]:
```
print("Evaluating LSTM Model 3")
test_loss, test_accuracy = lstm_mod3.evaluate(X_test, y_test, verbose=1)
print(f"Test Loss: {test_loss:.4f}, Test Accuracy: {test_accuracy:.4f}")

y_pred = np.argmax(lstm_mod3.predict([X_test]),1)

print(f"Classification Report for LSTM Model 3:")
print(classification_report(y_test, y_pred))
```

```
Evaluating LSTM Model 3
7/7 [==============================] - 0s 58ms/step - loss: 1.2066 - acc: 0.6684
Test Loss: 1.2066, Test Accuracy: 0.6684
7/7 [==============================] - 2s 35ms/step
Classification Report for LSTM Model 3:
              precision    recall  f1-score   support
```

```
           0       0.33      0.25      0.29         4
           1       0.73      0.71      0.72        42
           2       0.88      0.89      0.88        63
           3       0.00      0.00      0.00         2
           4       0.00      0.00      0.00         2
           5       0.40      0.29      0.33         7
           6       0.00      0.00      0.00         3
           7       0.59      0.59      0.59        22
           8       0.62      0.42      0.50        12
           9       0.33      0.55      0.41        11
          11       0.25      0.50      0.33         4
          12       0.60      0.55      0.57        11
          13       0.71      0.77      0.74        13

    accuracy                           0.67       196
   macro avg       0.42      0.42      0.41       196
weighted avg       0.67      0.67      0.66       196

/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

8 LSTM Model 4

[138]:
```
from keras.layers import LSTM, Dense, Embedding, Dropout
from keras.models import Sequential

lstm_mod4 = Sequential()
embedding_layer = Embedding(vocab_length, 100, weights=[embedding_matrix],␣
 ↪input_length=maxlen , trainable=False)
lstm_mod4.add(embedding_layer)
lstm_mod4.add(LSTM(256, return_sequences=True))
lstm_mod4.add(Dropout(0.4))
```

```
lstm_mod4.add(LSTM(128))
lstm_mod4.add(Dense(14, activation='softmax'))
lstm_mod4.compile(optimizer='adam', loss=tf.keras.losses.
 ↪SparseCategoricalCrossentropy(), metrics=['acc'])
```

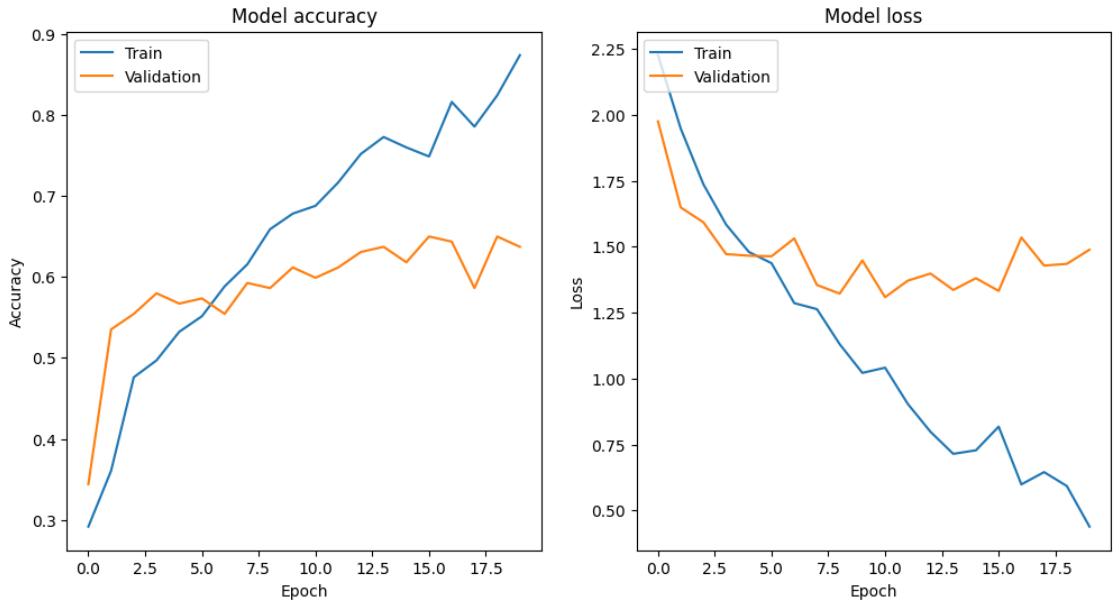
[139]:
```
print(f"Summary of LSTM Model 4:")
print(lstm_mod4.summary())
```

```
Summary of LSTM Model 4:
Model: "sequential_16"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding_16 (Embedding)    (None, 30, 100)           182300

 lstm_36 (LSTM)              (None, 30, 256)           365568

 dropout_24 (Dropout)        (None, 30, 256)           0

 lstm_37 (LSTM)              (None, 128)               197120

 dense_20 (Dense)            (None, 14)                1806

=================================================================
Total params: 746794 (2.85 MB)
Trainable params: 564494 (2.15 MB)
Non-trainable params: 182300 (712.11 KB)
_________________________________________________________________
None
```

[140]:
```
history = lstm_mod4.fit(X_train, y_train, epochs=20, verbose=1,␣
 ↪validation_split=0.2)
plot_history(history)
```

```
Epoch 1/20
20/20 [==============================] - 8s 205ms/step - loss: 2.2259 - acc:
0.2917 - val_loss: 1.9749 - val_acc: 0.3439
Epoch 2/20
20/20 [==============================] - 4s 221ms/step - loss: 1.9481 - acc:
0.3606 - val_loss: 1.6488 - val_acc: 0.5350
Epoch 3/20
20/20 [==============================] - 4s 221ms/step - loss: 1.7365 - acc:
0.4760 - val_loss: 1.5923 - val_acc: 0.5541
Epoch 4/20
20/20 [==============================] - 3s 153ms/step - loss: 1.5837 - acc:
0.4968 - val_loss: 1.4718 - val_acc: 0.5796
Epoch 5/20
20/20 [==============================] - 3s 159ms/step - loss: 1.4801 - acc:
```

```
0.5321 - val_loss: 1.4658 - val_acc: 0.5669
Epoch 6/20
20/20 [==============================] - 3s 176ms/step - loss: 1.4373 - acc:
0.5513 - val_loss: 1.4636 - val_acc: 0.5732
Epoch 7/20
20/20 [==============================] - 5s 268ms/step - loss: 1.2860 - acc:
0.5881 - val_loss: 1.5312 - val_acc: 0.5541
Epoch 8/20
20/20 [==============================] - 3s 152ms/step - loss: 1.2631 - acc:
0.6154 - val_loss: 1.3548 - val_acc: 0.5924
Epoch 9/20
20/20 [==============================] - 3s 153ms/step - loss: 1.1305 - acc:
0.6587 - val_loss: 1.3222 - val_acc: 0.5860
Epoch 10/20
20/20 [==============================] - 3s 155ms/step - loss: 1.0216 - acc:
0.6779 - val_loss: 1.4476 - val_acc: 0.6115
Epoch 11/20
20/20 [==============================] - 5s 234ms/step - loss: 1.0413 - acc:
0.6875 - val_loss: 1.3086 - val_acc: 0.5987
Epoch 12/20
20/20 [==============================] - 4s 213ms/step - loss: 0.9039 - acc:
0.7163 - val_loss: 1.3712 - val_acc: 0.6115
Epoch 13/20
20/20 [==============================] - 3s 161ms/step - loss: 0.7982 - acc:
0.7516 - val_loss: 1.3982 - val_acc: 0.6306
Epoch 14/20
20/20 [==============================] - 3s 149ms/step - loss: 0.7147 - acc:
0.7724 - val_loss: 1.3360 - val_acc: 0.6369
Epoch 15/20
20/20 [==============================] - 3s 170ms/step - loss: 0.7281 - acc:
0.7596 - val_loss: 1.3805 - val_acc: 0.6178
Epoch 16/20
20/20 [==============================] - 5s 270ms/step - loss: 0.8178 - acc:
0.7484 - val_loss: 1.3323 - val_acc: 0.6497
Epoch 17/20
20/20 [==============================] - 3s 160ms/step - loss: 0.5988 - acc:
0.8157 - val_loss: 1.5349 - val_acc: 0.6433
Epoch 18/20
20/20 [==============================] - 3s 155ms/step - loss: 0.6454 - acc:
0.7853 - val_loss: 1.4284 - val_acc: 0.5860
Epoch 19/20
20/20 [==============================] - 3s 155ms/step - loss: 0.5928 - acc:
0.8237 - val_loss: 1.4347 - val_acc: 0.6497
Epoch 20/20
20/20 [==============================] - 5s 248ms/step - loss: 0.4388 - acc:
0.8734 - val_loss: 1.4886 - val_acc: 0.6369
```



[141]:
```
print("Evaluating LSTM Model 4")
test_loss, test_accuracy = lstm_mod4.evaluate(X_test, y_test, verbose=1)
print(f"Test Loss: {test_loss:.4f}, Test Accuracy: {test_accuracy:.4f}")

y_pred = np.argmax(lstm_mod4.predict([X_test]),1)

print(f"Classification Report for LSTM Model 4:")
print(classification_report(y_test, y_pred))
```

```
Evaluating LSTM Model 4
7/7 [==============================] - 0s 43ms/step - loss: 1.1644 - acc: 0.6888
Test Loss: 1.1644, Test Accuracy: 0.6888
7/7 [==============================] - 1s 51ms/step
Classification Report for LSTM Model 4:
              precision    recall  f1-score   support

           0       0.25      0.75      0.38         4
           1       0.78      0.74      0.76        42
           2       0.79      0.95      0.86        63
           3       0.00      0.00      0.00         2
           4       0.50      0.50      0.50         2
           5       1.00      0.57      0.73         7
           6       0.00      0.00      0.00         3
           7       0.50      0.41      0.45        22
           8       0.47      0.58      0.52        12
           9       1.00      0.27      0.43        11
          11       0.00      0.00      0.00         4
```

```
          12       0.75      0.55      0.63        11
          13       0.73      0.85      0.79        13

    accuracy                           0.69       196
   macro avg       0.52      0.47      0.46       196
weighted avg       0.70      0.69      0.67       196

/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

9 LSTM Model 5

[142]:
```
lstm_mod5 = Sequential()
embedding_layer = Embedding(vocab_length, 100, weights=[embedding_matrix],␣
 ↪input_length=maxlen, trainable=False)
lstm_mod5.add(embedding_layer)
lstm_mod5.add(LSTM(128, return_sequences=True))
lstm_mod5.add(Dropout(0.6))
lstm_mod5.add(LSTM(128, return_sequences=True))
lstm_mod5.add(Dropout(0.4))
lstm_mod5.add(LSTM(64))
lstm_mod5.add(Dense(32, activation='relu'))
lstm_mod5.add(Dropout(0.2))
lstm_mod5.add(Dense(14, activation='softmax'))

lstm_mod5.compile(optimizer='adam', loss=tf.keras.losses.
 ↪SparseCategoricalCrossentropy(), metrics=['acc'])
```

[143]:
```
print(f"Summary of LSTM Model 5:")
print(lstm_mod5.summary())
```

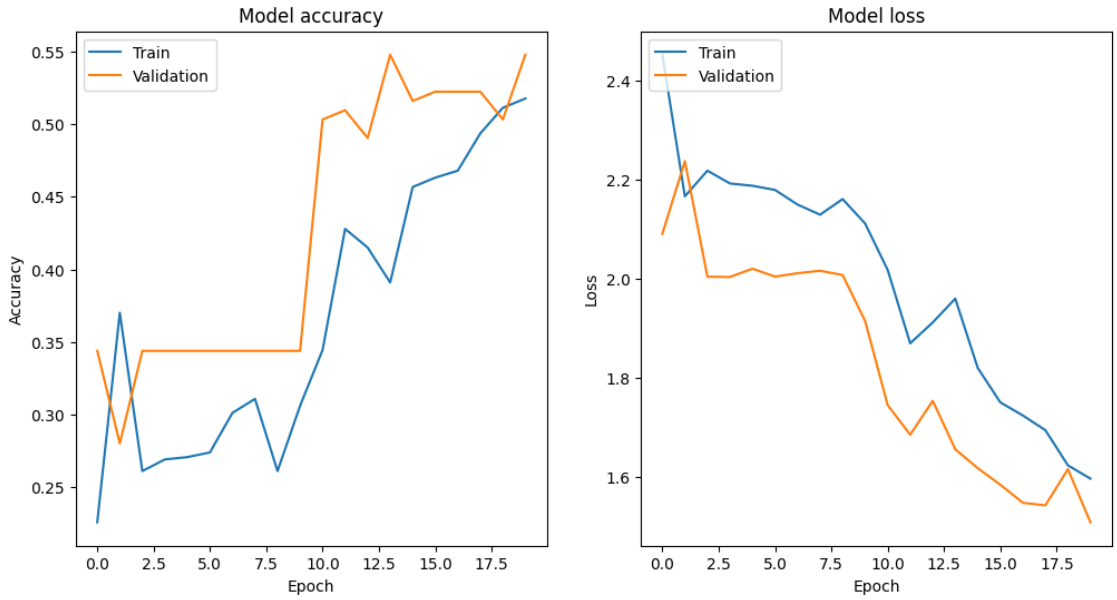
```
Summary of LSTM Model 5:
Model: "sequential_17"
_________________________________________________________________
```

```
 Layer (type)                Output Shape              Param #
=================================================================
 embedding_17 (Embedding)    (None, 30, 100)           182300

 lstm_38 (LSTM)              (None, 30, 128)           117248

 dropout_25 (Dropout)        (None, 30, 128)           0

 lstm_39 (LSTM)              (None, 30, 128)           131584

 dropout_26 (Dropout)        (None, 30, 128)           0

 lstm_40 (LSTM)              (None, 64)                49408

 dense_21 (Dense)            (None, 32)                2080

 dropout_27 (Dropout)        (None, 32)                0

 dense_22 (Dense)            (None, 14)                462

=================================================================
Total params: 483082 (1.84 MB)
Trainable params: 300782 (1.15 MB)
Non-trainable params: 182300 (712.11 KB)
_________________________________________________________________
None
```

[144]:
```
history = lstm_mod5.fit(X_train, y_train, epochs=20, verbose=1,␣
↪validation_split=0.2)
plot_history(history)
```

```
Epoch 1/20
20/20 [==============================] - 14s 231ms/step - loss: 2.4532 - acc:
0.2260 - val_loss: 2.0917 - val_acc: 0.3439
Epoch 2/20
20/20 [==============================] - 2s 122ms/step - loss: 2.1673 - acc:
0.3702 - val_loss: 2.2382 - val_acc: 0.2803
Epoch 3/20
20/20 [==============================] - 5s 241ms/step - loss: 2.2191 - acc:
0.2612 - val_loss: 2.0050 - val_acc: 0.3439
Epoch 4/20
20/20 [==============================] - 3s 153ms/step - loss: 2.1932 - acc:
0.2692 - val_loss: 2.0044 - val_acc: 0.3439
Epoch 5/20
20/20 [==============================] - 2s 121ms/step - loss: 2.1886 - acc:
0.2708 - val_loss: 2.0212 - val_acc: 0.3439
Epoch 6/20
20/20 [==============================] - 2s 123ms/step - loss: 2.1802 - acc:
```

```
0.2740 - val_loss: 2.0052 - val_acc: 0.3439
Epoch 7/20
20/20 [==============================] - 2s 120ms/step - loss: 2.1506 - acc:
0.3013 - val_loss: 2.0120 - val_acc: 0.3439
Epoch 8/20
20/20 [==============================] - 4s 197ms/step - loss: 2.1302 - acc:
0.3109 - val_loss: 2.0171 - val_acc: 0.3439
Epoch 9/20
20/20 [==============================] - 4s 199ms/step - loss: 2.1617 - acc:
0.2612 - val_loss: 2.0084 - val_acc: 0.3439
Epoch 10/20
20/20 [==============================] - 2s 124ms/step - loss: 2.1124 - acc:
0.3061 - val_loss: 1.9155 - val_acc: 0.3439
Epoch 11/20
20/20 [==============================] - 2s 113ms/step - loss: 2.0187 - acc:
0.3446 - val_loss: 1.7458 - val_acc: 0.5032
Epoch 12/20
20/20 [==============================] - 2s 122ms/step - loss: 1.8706 - acc:
0.4279 - val_loss: 1.6862 - val_acc: 0.5096
Epoch 13/20
20/20 [==============================] - 3s 128ms/step - loss: 1.9127 - acc:
0.4151 - val_loss: 1.7544 - val_acc: 0.4904
Epoch 14/20
20/20 [==============================] - 4s 225ms/step - loss: 1.9608 - acc:
0.3910 - val_loss: 1.6567 - val_acc: 0.5478
Epoch 15/20
20/20 [==============================] - 3s 162ms/step - loss: 1.8207 - acc:
0.4567 - val_loss: 1.6185 - val_acc: 0.5159
Epoch 16/20
20/20 [==============================] - 2s 120ms/step - loss: 1.7514 - acc:
0.4631 - val_loss: 1.5851 - val_acc: 0.5223
Epoch 17/20
20/20 [==============================] - 2s 124ms/step - loss: 1.7248 - acc:
0.4679 - val_loss: 1.5487 - val_acc: 0.5223
Epoch 18/20
20/20 [==============================] - 2s 118ms/step - loss: 1.6952 - acc:
0.4936 - val_loss: 1.5435 - val_acc: 0.5223
Epoch 19/20
20/20 [==============================] - 4s 193ms/step - loss: 1.6242 - acc:
0.5112 - val_loss: 1.6166 - val_acc: 0.5032
Epoch 20/20
20/20 [==============================] - 4s 203ms/step - loss: 1.5974 - acc:
0.5176 - val_loss: 1.5093 - val_acc: 0.5478
```



[145]:
```
print("Evaluating LSTM Model 5")
test_loss, test_accuracy = lstm_mod5.evaluate(X_test, y_test, verbose=1)
print(f"Test Loss: {test_loss:.4f}, Test Accuracy: {test_accuracy:.4f}")

y_pred = np.argmax(lstm_mod5.predict([X_test]),1)

print(f"Classification Report for LSTM Model 5:")
print(classification_report(y_test, y_pred))
```

```
Evaluating LSTM Model 5
7/7 [==============================] - 0s 33ms/step - loss: 1.5558 - acc: 0.5102
Test Loss: 1.5558, Test Accuracy: 0.5102
7/7 [==============================] - 1s 32ms/step
Classification Report for LSTM Model 5:
              precision    recall  f1-score   support

           0       0.00      0.00      0.00         4
           1       0.44      0.93      0.60        42
           2       0.76      0.89      0.82        63
           3       0.00      0.00      0.00         2
           4       0.00      0.00      0.00         2
           5       0.00      0.00      0.00         7
           6       0.00      0.00      0.00         3
           7       0.31      0.18      0.23        22
           8       0.33      0.08      0.13        12
           9       0.00      0.00      0.00        11
          11       0.00      0.00      0.00         4
          12       0.00      0.00      0.00        11
```

```
          13       0.00      0.00      0.00        13

    accuracy                           0.51       196
   macro avg       0.14      0.16      0.14       196
weighted avg       0.39      0.51      0.42       196

/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

10 Saving all models

[146]:
```
lstm_mod1.save('lstm_mod1.h5')
lstm_mod2.save('lstm_mod2.h5')
lstm_mod3.save('lstm_mod3.h5')
lstm_mod4.save('lstm_mod4.h5')
lstm_mod5.save('lstm_mod5.h5')
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/engine/training.py:3103:
UserWarning: You are saving your model as an HDF5 file via `model.save()`. This
file format is considered legacy. We recommend using instead the native Keras
format, e.g. `model.save('my_model.keras')`.
  saving_api.save_model(
```

11 Creating Ensemble model

[147]:
```
from keras.models import load_model

# List to store imported models
imported_models = []

# Import each saved model
for i in range(1, 6):  # Assuming you saved models with filenames 'lstm_model_1.
↪h5' to 'lstm_model_5.h5'
```

```
    model = load_model(f'lstm_mod{i}.h5')
    imported_models.append(model)
    print(f"Model lstm_mod{i}.h5 imported successfully.")

# Now you can use the imported_models list to access each imported model
```

```
Model lstm_mod1.h5 imported successfully.
Model lstm_mod2.h5 imported successfully.
Model lstm_mod3.h5 imported successfully.
Model lstm_mod4.h5 imported successfully.
Model lstm_mod5.h5 imported successfully.
```

[148]:
```
accuracies = [0.66,0.61,0.67,0.69,0.51]
```

[149]:
```
lstm_mod5.predict([X_test])
```

```
7/7 [==============================] - 1s 90ms/step
```

[149]:
```
array([[0.04900096, 0.09765861, 0.0726105 , …, 0.05974049, 0.04106464,
        0.18752387],
       [0.00425106, 0.61880237, 0.03762168, …, 0.00620735, 0.11409575,
        0.06027661],
       [0.00422755, 0.6184294 , 0.03912844, …, 0.00611277, 0.11466012,
        0.05957803],
       …,
       [0.00160304, 0.02657258, 0.74229354, …, 0.00325281, 0.01583083,
        0.01726529],
       [0.05556928, 0.0674236 , 0.07131706, …, 0.07121769, 0.03246687,
        0.15094814],
       [0.02253999, 0.29879975, 0.04895258, …, 0.022699  , 0.08950006,
        0.14556843]], dtype=float32)
```

[157]:
```
# Calculate weights based on accuracies
total_accuracy = sum(accuracies)
weights = [acc / total_accuracy for acc in accuracies]
# List to store predictions from each model
ensemble_predictions = []
# Get predictions from each model
for model in imported_models:
    y_pred_prob = model.predict([X_test])
    ensemble_predictions.append(y_pred_prob)

ensemble_predictions_3d = np.array(ensemble_predictions)

# Calculate the weighted average along the first axis (axis=0)
weighted_predictions = np.average(ensemble_predictions_3d, axis=0,␣
 ↪weights=weights)
```

```
y_pred = np.argmax(weighted_predictions,1)


# Print performance report for the ensemble model
print("Performance Report for Ensemble Model:")

from sklearn.metrics import classification_report
from sklearn.metrics import accuracy_score

# Calculate ensemble accuracy on test data
ensemble_accuracy = accuracy_score(y_test, y_pred)

# Print test accuracy
print("Test Accuracy for Ensemble Model:", ensemble_accuracy)
print(classification_report(y_test, y_pred))
```

```
7/7 [==============================] - 0s 59ms/step
7/7 [==============================] - 1s 68ms/step
7/7 [==============================] - 0s 59ms/step
7/7 [==============================] - 0s 62ms/step
7/7 [==============================] - 0s 61ms/step
Performance Report for Ensemble Model:
Test Accuracy for Ensemble Model: 0.7397959183673469
              precision    recall  f1-score   support

           0       0.50      0.75      0.60         4
           1       0.69      0.86      0.77        42
           2       0.86      0.94      0.89        63
           3       0.00      0.00      0.00         2
           4       1.00      0.50      0.67         2
           5       0.75      0.43      0.55         7
           6       0.00      0.00      0.00         3
           7       0.65      0.59      0.62        22
           8       0.62      0.67      0.64        12
           9       0.67      0.36      0.47        11
          11       1.00      0.25      0.40         4
          12       0.73      0.73      0.73        11
          13       0.69      0.69      0.69        13

    accuracy                           0.74       196
   macro avg       0.63      0.52      0.54       196
weighted avg       0.73      0.74      0.72       196


/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
```

```
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344:
UndefinedMetricWarning: Precision and F-score are ill-defined and being set to
0.0 in labels with no predicted samples. Use `zero_division` parameter to
control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

12 Testing the model manually

[161]:
```
def evaluate_sentiment(requirement, tokenizer, max_length, ensemble_models,␣
↪weights):
    # Tokenize the review
    tokenized_review = tokenizer.texts_to_sequences([requirement])

    # Pad sequences
    padded_review = pad_sequences(tokenized_review, maxlen=max_length,␣
↪padding='post')

    # List to store predictions from each model
    ensemble_predictions = []

    # Get predictions from each model
    for model in ensemble_models:
        y_pred_prob = model.predict(padded_review)
        ensemble_predictions.append(y_pred_prob)

    ensemble_predictions_3d = np.array(ensemble_predictions)

    # Calculate the weighted average along the first axis (axis=0)
    weighted_predictions = np.average(ensemble_predictions_3d, axis=0,␣
↪weights=weights)

    y_pred = np.argmax(weighted_predictions,1)


    return encoder.classes_[y_pred[0]]
```

[176]:
```
# Define a sample review
sample_requirement = X[2]

print("Requirement:", sample_requirement)
```

```
print("Actual Software Requirement:", encoder.classes_[y[2]])

# Call the evaluate_sentiment function
predicted_sentiment = evaluate_sentiment(sample_requirement, word_tokenizer,␣
 ↪30, imported_models, weights)

# Print the predicted sentiment
print("Predicted Software Requirement:", predicted_sentiment)
```

```
Requirement:  projected data must readable projection screen viewer must able
read event activity data viewing distance
Actual Software Requirement: US
1/1 [==============================] - 0s 111ms/step
1/1 [==============================] - 0s 110ms/step
1/1 [==============================] - 0s 112ms/step
1/1 [==============================] - 0s 139ms/step
1/1 [==============================] - 0s 151ms/step
Predicted Software Requirement: US
```

[ ]: